

NASA Technical Memorandum 88961

# A Distributed Data Acquisition System for Aeronautics Test Facilities

(NASA-TM-88961) A DISTRIBUTED DATA  
ACQUISITION SYSTEM FOR AERONAUTICS TEST  
FACILITIES (NASA) 8 p CSCL 14B

N87-16851

G3/09 Unclass  
43867

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Prepared for the  
International Instrumentation Symposium  
sponsored by the Instrument Society of America  
Las Vegas, Nevada, May 3-8, 1987



## A DISTRIBUTED DATA ACQUISITION SYSTEM FOR AERONAUTICS TEST FACILITIES

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### ABSTRACT

The NASA Lewis Research Center is in the process of installing a new data acquisition and display system. This new system will provide small and medium sized aeronautics test facilities with a state-of-the-art real-time data acquisition and display system.

The new data system will provide for the acquisition of signals from a variety of instrumentation sources. They include analog measurements of temperatures, pressures, and other steady state voltage inputs; frequency inputs to measure speed and flow; discrete I/O for significant events, and modular instrument systems such as multiplexed pressure modules or electronic instrumentation with a IEEE 488 interface. The data system is designed to acquire data, convert it to engineering units, compute test dependent performance calculations, limit check selected channels or calculations, and display the information in alphanumeric or graphical form with a cycle time of one second for the alphanumeric data.

This paper describes the system configuration, its salient features, and the expected impact on testing.

### INTRODUCTION

In the late 70's, NASA Lewis Research Center (LeRC) developed a centralized data acquisition system called Escort. The Escort system was shortly upgraded to a Escort II system which provided data acquisition and display for small aeronautics test facilities. The name Escort was chosen to imply the system was user friendly and would guide the user with menus and prompts. Escort II utilizes a centralized computer (mini-class) remotely located in the Research Analysis Center (RAC) building. This configuration requires each scan of raw data to be transmitted from the facility to the centralized computer where it is processed and returned to the facility to be displayed in engineering units. The current Escort data system cannot be used for secure-data testing because NASA guidelines do not permit transmission of data outside the secure area.

Increasing cost of power and fuel was the driving force to improve the efficiency of the large test facilities in the early 80's. Escort III was developed for the large tunnels and full scale engine test facilities. Escort III's hardware configuration remained essentially the same as the Escort II. The computers were replaced with larger, faster machines; the volume of input data was increased and the systems capabilities were enhanced. Escort III's real-time displays provide the research engineer with a means to evaluate his critical data and make corrections relevant to his test matrix and therefore, decrease the length of his test runs. There are currently 60 Escort II and 5 Escort III data acquisition systems at Lewis Research Center.

An improved data acquisition system evolved from the Escort II and Escort III systems and is currently being installed at Lewis Research Center. This new system, designated Escort D, was designed to accommodate small to medium sized aeronautics test facilities currently testing rotating machinery. Rotating machinery requires closer monitoring of the health parameters. A faster scan rate will provide faster limit checking of health parameters and real-time updates of the operators display. Smaller, more powerful hardware, high density storage devices, low cost hardware, and a need for secure-data testing have changed the hardware configuration of the new data acquisition system. The Escort D has a distributed architecture with a microcomputer located in each test facility. Each facility data system has the ability to be a stand-alone system for secure-data testing.

### GENERAL SYSTEM DESCRIPTION

The new system configuration utilizes a distributed architecture approach. The configuration (Fig. 1), includes a facility microcomputer connected through a network to a centrally located computer configuration remotely located in the RAC building. During a research test, the facility microcomputer performs as a stand-alone data system while executing all real-time tasks. The centrally located cluster will be used for application software development, downloading of developed software modules, uploading and storage

of facility tables and files, post processing of data, and transmitting data to a data collector for archival storage.

The cluster consists of two mass storage subsystems connected to four computers through a star coupler. The four computers are nodes of a baseband Local Area Network (LAN). The cluster is configured in this manner to provide a means for other nodes to communicate with any of the computers in the cluster on a 10 Megabyte communications path. The baseband coaxial cable provides the two way communications path between the cluster and the facilities through the router.

The router is a minicomputer that connects directly to the coaxial cable. It is a dedicated communications system in the LAN that transfers messages from nodes of the LAN to remote nodes (facility microcomputers) and vice versa. Unshielded twisted pair telephone line is the medium used to connect the router to the test facilities microcomputer. Modems are used to transmit and receive the signals from the remote stations.

As shown in Fig. 1, two of the computers in the cluster are connected to the CATV Lab Data Bus (broadband cable). The primary purpose of this connection is to provide a path from the test facility to a Data Collector for archival storage of research data readings. The facility microcomputer acquires and stores the data readings locally on disk. The data is automatically off-loaded from the disk through the router to the cluster; the cluster forwards the data to a Data Collector for archival storage. The link between the facility computer and the router would be disconnected for secure-data testing. When the system is used for secure-data testing, all real-time tasks, data storage, and post-run processing will be done on the facility computer in a secure environment.

#### FACILITY COMPUTER HARDWARE

The facility computer system was designed to provide control of all peripheral I/O devices and the run-time processing of all data related to the experiment. As shown in Fig. 2, the heart of the facility data system is a microcomputer with a 32 bit central processing unit, 3 Mbytes of MOS memory (expansion capability to 9 Mbytes), and a floating point processor to increase the speed of floating point operations.

The micro has three storage devices. A 71 Mbyte Winchester disk drive is provided to support file and data storage. There is a 95 Mbyte cartridge tape drive unit to backup the Winchester disk or store data. In addition, the system has a 800 Kbyte dual floppy disk drive which provides a means of loading software into the micro if the communications link with the cluster is lost.

There are two eight-line asynchronous, direct memory access (DMA) multiplexers provided to allow interconnection between the computer and serial, EIA RS-232-C interface devices. The system can support a maximum of four independent

alphanumeric display units. The majority of test facilities will have two color displays to monitor and display research information from the experiment. Individual digital displays (IDD's) are provided to display critical research parameters. The IDD's have a built-in daisy-chain connection scheme which enables a maximum of 32 IDD's to be connected on one serial, asynchronous, EIA RS-232-C line. Each IDD is a single 40 alphanumeric character display device that is individually addressable. Because of the daisy-chain scheme, the IDD's can be located anywhere in the control room and are not required to be clustered in a group.

The user communicates with the system by terminal or discrete input. The terminal is an asynchronous, 30 character per second console model whose function is to provide a logging of the interaction between the user and system. The second method of user-system interaction is through an off-the-shelf number entry panel (NEP). Special functions are assigned to the buttons to allow the user to control the operation of the data system. A few of the special functions are: record data, change the display page, display engineering units, display millivolts, and print a copy of the CRT.

A laser printer is provided to generate black and white hard copies of the data being displayed on the CRT's at a maximum rate of 12 pages-per-minute. In addition, the laser printer will generate hard copies, prior to the run, of calibration coefficients, conversion constants, and pre-run files.

There are two independent, DMA, IEEE 488 Bus Interfaces provided to interface the microcomputer to the General Purpose Interface Bus (GPIB) conforming to the IEEE 488 standard. One of these interfaces will be used in conjunction with an electronically scanned pressure system. A maximum of 1024 pressure ports can be recorded by the facility data system. Each pressure port has its own pressure transducer. The transducers are multiplexed, data converted to engineering units and the result passed to the micro over the IEEE 488 interface. The second interface is used to communicate with commercially available devices.

A front end subsystem provides the path for analog voltages from facility instrumentation. The subsystem provides the multiplexing with a throughput up to 10 kHz. A maximum of 512 analog channels can be input at gain ranges of 5 mV, 10 mV, 20 mV, . . . .2.56 V, 5.12 V, and 10.24 V. The subsystem can also provide for digital I/O, discrete I/O, and frequency measurements through standard plug-in cards.

For secure-data testing, a portable storage subsystem will be connected to the microcomputer and the link to the router will be disconnected. The portable subsystem will consist of a disk unit capable of recording 52 Mbytes of formatted user data on either a 26 Mbyte fixed disk or a 26 Mbyte removable disk. The portable storage subsystem also includes a magnetic tape, capable of storing 46 Mbytes of unformatted data.

## FACILITY COMPUTER SOFTWARE

The Escort D software supports two separate and independent environments, "run-time functions" and "off-line pre-run functions." A software flow diagram of a typical scan of data is shown in Fig. 3. A task acquires the raw data from the front end subsystem and all the modular inputs. The raw data is packaged into an acceptable format for the run-time monitor task. This task converts the raw data into engineering units, solves the performance calculations, limit checks the designated data, and passes a snapshot of the engineering units to the history file to be saved.

The primary purpose of the history file is to provide a recorded history of a significant event. The file can be a history of prefailure and postfailure data. The history file is a circular file that can contain both sampled and computed data. The files input rate can be either the same as the systems or some multiple of it. Normally the file is always active, however, it can be started or stopped by operator action, preprogrammed limit violation, or the occurrence of a significant event.

The results of the run-time monitor task (conversions, performance calculations, and limit checks) are made available to either the display task or both the display and data recording tasks. The display task massages the data into the correct format for the CRT displays and IDD's. Converted and computed data will be displayed at a variable, selectable rate. The minimum update rate is once-per-second for all channels. The data recording task, packages the data reading into the correct format and sends it to a Data Collector for archival storage. A record of data can include results of performance calculations as well as the acquired channel data.

Software support for "off-line pre-run functions" consists of simultaneous instrumentation calibration with selectable statistical analysis. User friendly editors are available to create or modify run-time tables or displays. Tasks exist which generate selectable displays of "groups of channels" in raw counts, millivolts, or engineering units to aid the technician in troubleshooting instrumentation. An additional pre-run group of tasks provides for the simulation of an actual test run with full support of all peripherals. The simulation uses known pre-defined conditions from either a file created by the user or a playback of previously recorded test data. This simulation is a powerful checkout tool since it can be used to verify the validity of software modifications, overall system readiness and as an aid in training facility users and operators.

## SUMMARY

This modern state-of-the-art data acquisition system will provide for the acquisition and display, in real-time, of a variety of input devices and types. The system has the capability of being either a node in a distributed network or a stand-alone system. The facility data system is self contained during secure-data testing. If a failure occurs in the communications path to the cluster, Escort D will be a stand-alone system and store the research data locally. The system has been designed to be user friendly by providing a prompting environment. The improved flexibility in the software will provide faster turn around time to accommodate configuration changes in the experiment. Faster update rates of the displays and limit checking, will enhance setting test conditions and provide better protection of the experiment.

The Escort D data acquisition system is a major improvement in the data recording capabilities for small and medium sized research facilities at NASA Lewis Research Center.

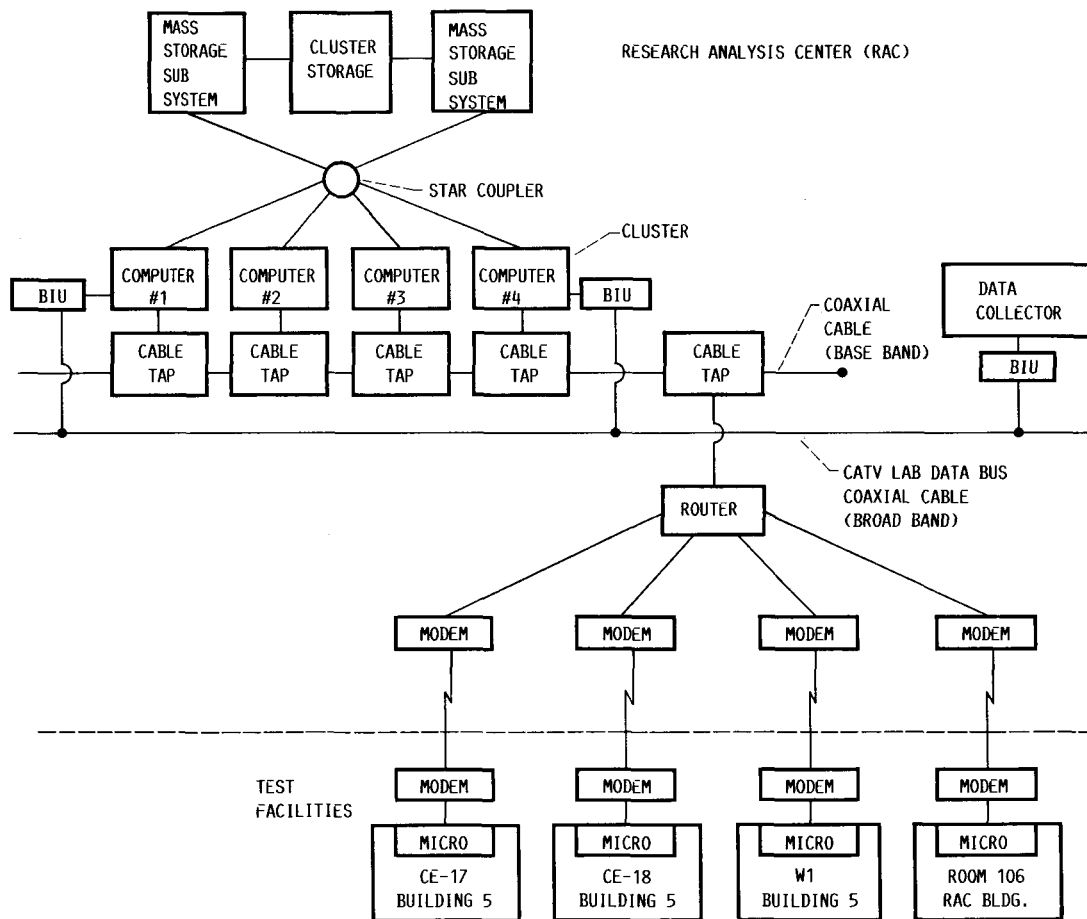


FIGURE 1.- ESCORT D COMMUNICATIONS DIAGRAM.

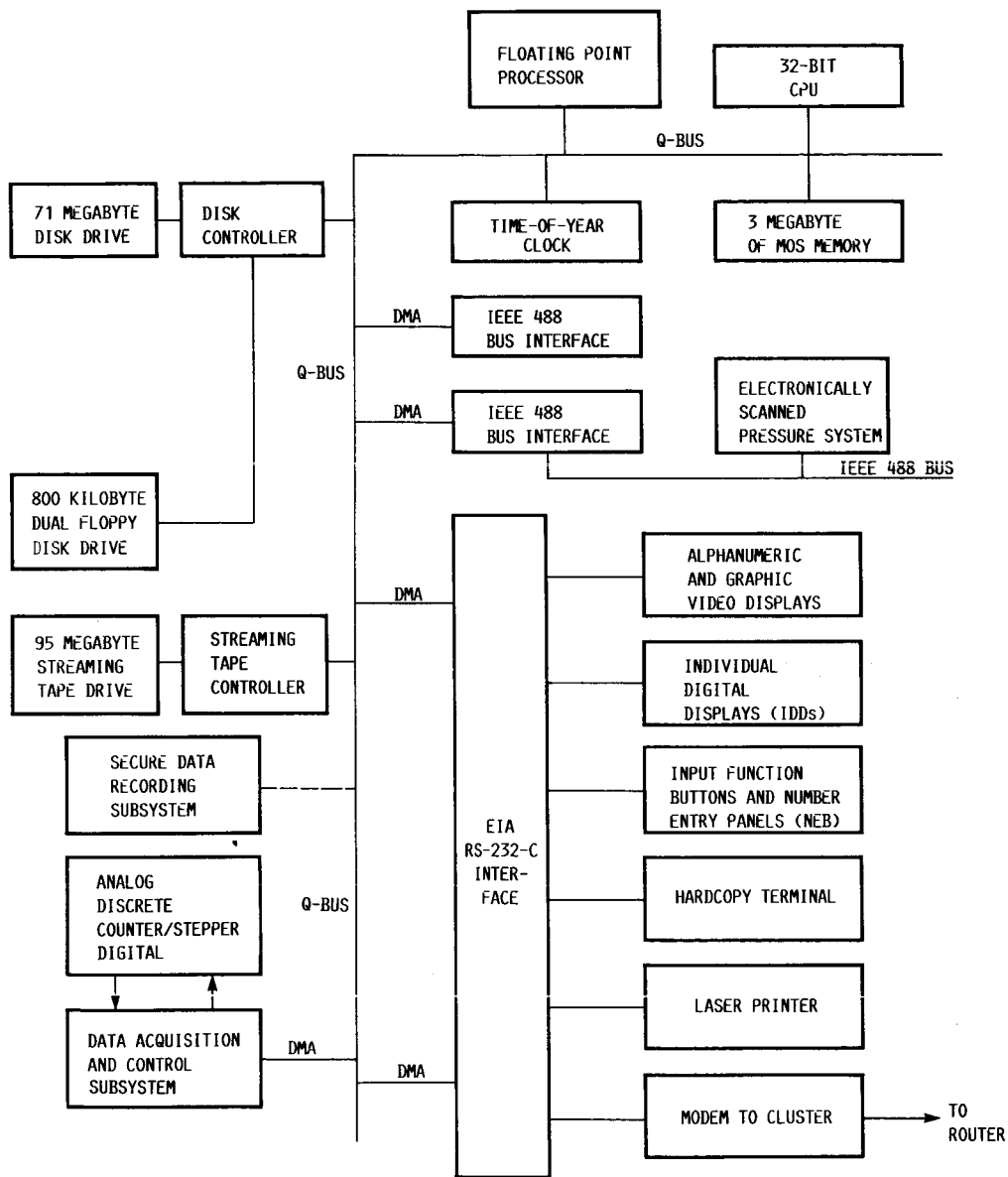


FIGURE 2.- FACILITY COMPUTER DIAGRAM.

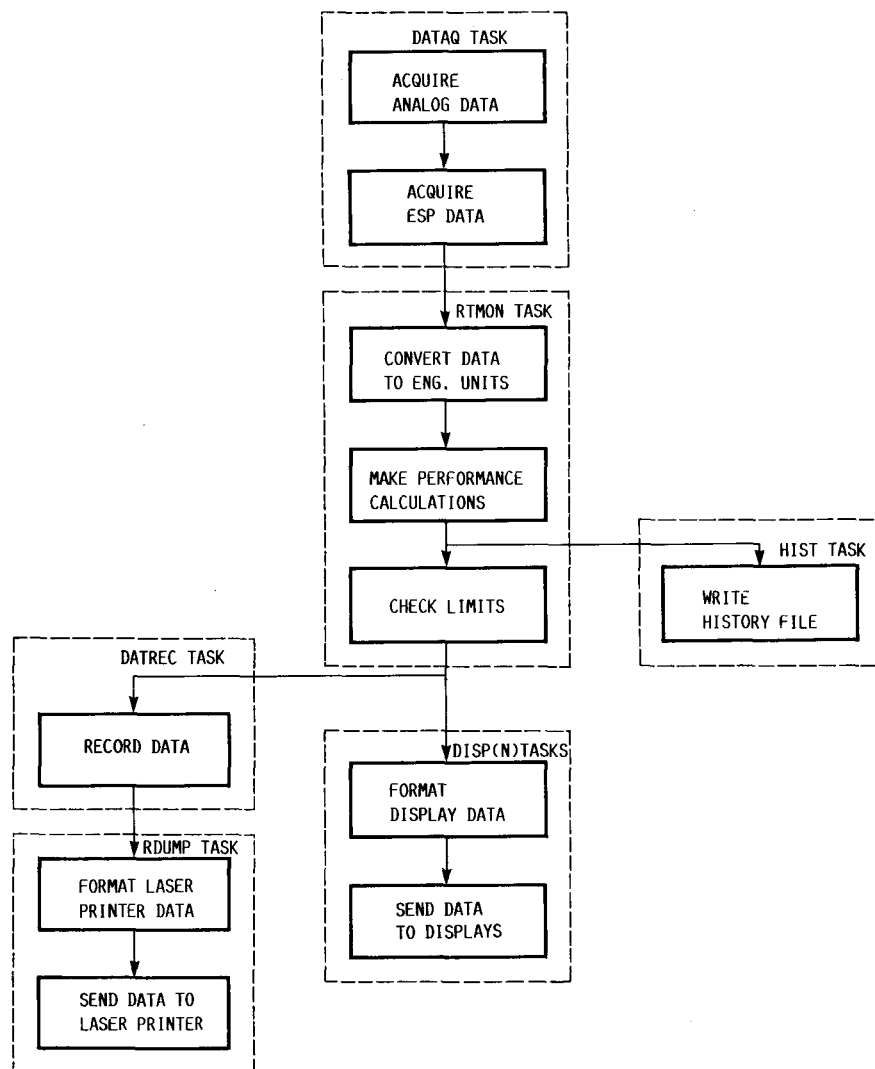


FIGURE 3.- A TYPICAL DATA FLOW SCAN.

1. Report No. <b>NASA TM-88961</b>		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle  <b>A Distributed Data Acquisition System for Aeronautics Test Facilities</b>				5. Report Date	
				6. Performing Organization Code <b>505-62-38</b>	
7. Author(s) <b>Dennis L. Fronek, Robert N. Setter, Philip Z. Blumenthal, and Robert R. Smalley</b>				8. Performing Organization Report No. <b>E-3417</b>	
				10. Work Unit No.	
9. Performing Organization Name and Address <b>National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio 44135</b>				11. Contract or Grant No.	
				13. Type of Report and Period Covered <b>Technical Memorandum</b>	
12. Sponsoring Agency Name and Address <b>National Aeronautics and Space Administration Washington, D.C. 20546</b>				14. Sponsoring Agency Code	
15. Supplementary Notes <b>Prepared for the International Instrumentation Symposium, sponsored by the Instrument Society of America, Las Vegas, Nevada, May 3-8, 1987.</b>					
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17. Key Words (Suggested by Author(s))  <b>Distributed data Acquisition system</b>			18. Distribution Statement  <b>Unclassified - unlimited STAR Category 09</b>		
19. Security Classif. (of this report) <b>Unclassified</b>		20. Security Classif. (of this page) <b>Unclassified</b>		21. No. of pages	
				22. Price*	